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Iwanaga

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[45] **Date of Patent: Dec. 5, 1995**

[54] **ACCUMULATOR FUEL INJECTION APPARATUS**

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[73] Assignee: **Nippondenso Co., Ltd.**, Kariya, Japan

[21] Appl. No.: **323,226**

[22] Filed: **Oct. 14, 1994**

Related U.S. Application Data

[63] Continuation-in-part of Ser. No. 103,698, Aug. 10, 1993, abandoned.

[30] **Foreign Application Priority Data**

Aug. 11, 1992 [JP] Japan 4-214080

[51] **Int. Cl.**^{6} **F02M 45/02**

[52] **U.S. Cl.** **239/96**; 239/533.4; 239/533.8

[58] **Field of Search** 239/88–96, 533.4, 239/533.8, 585.1

[56] **References Cited**

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Primary Examiner—Andres Kashnikow
Assistant Examiner—Kevin P. Weldon
Attorney, Agent, or Firm—Cushman, Darby & Cushman

[57] **ABSTRACT**

An accumulator fuel injection apparatus in which a nozzle element is divided into a first nozzle having one end side of said nozzle element and a second nozzle having the other end side of the nozzle element. The accumulator fuel injection apparatus comprises a stopper for setting a maximum movement position of the first nozzle toward the second nozzle, a second pressure control chamber communicating with a first pressure control chamber and forming a predetermined space or interval through which the first nozzle and the second nozzle are spaced away from each other under a condition that the first nozzle is arranged at the maximum movement position, and delay apparatus for delaying reduction of pressure within the first pressure control chamber due to the fact that fluid flows into a low-pressure chamber from the first pressure control chamber upon communication of the first pressure control chamber and the low-pressure chamber with each other. It is possible to easily perform operation of setting an amount of pre-lift of the nozzle needle which decides an injection rate, and operation of assembling constitutional elements thereof.

5 Claims, 8 Drawing Sheets

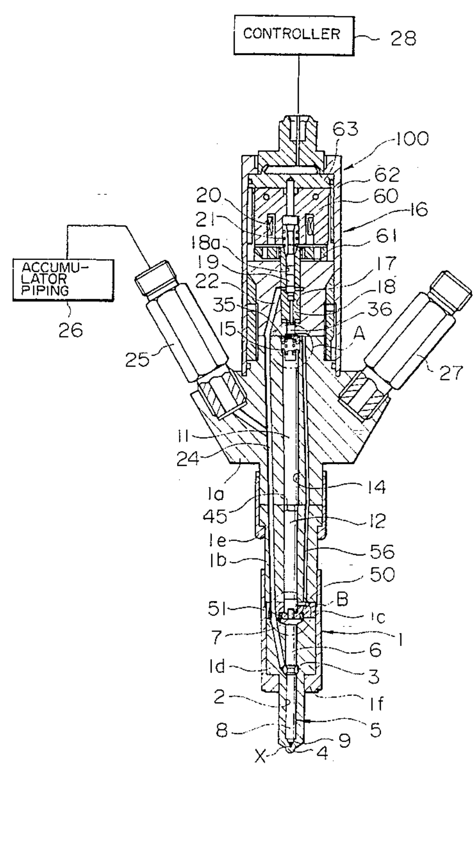
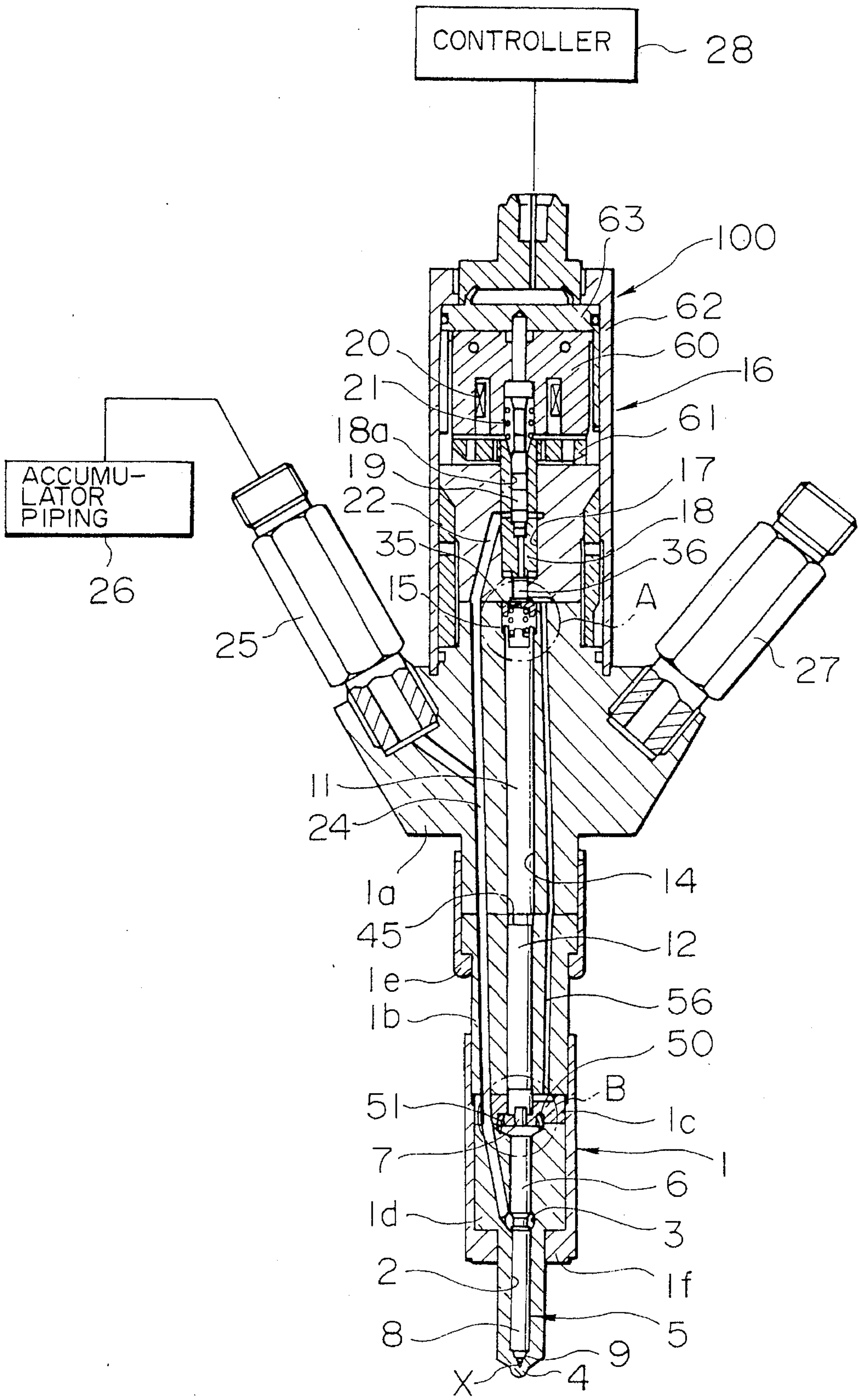


FIG. 1


CONTROLLER
28
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LATOR
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100
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60
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35
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15
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27
11
24
1a
14
45
12
1e
56
1b
50
B
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1c
7
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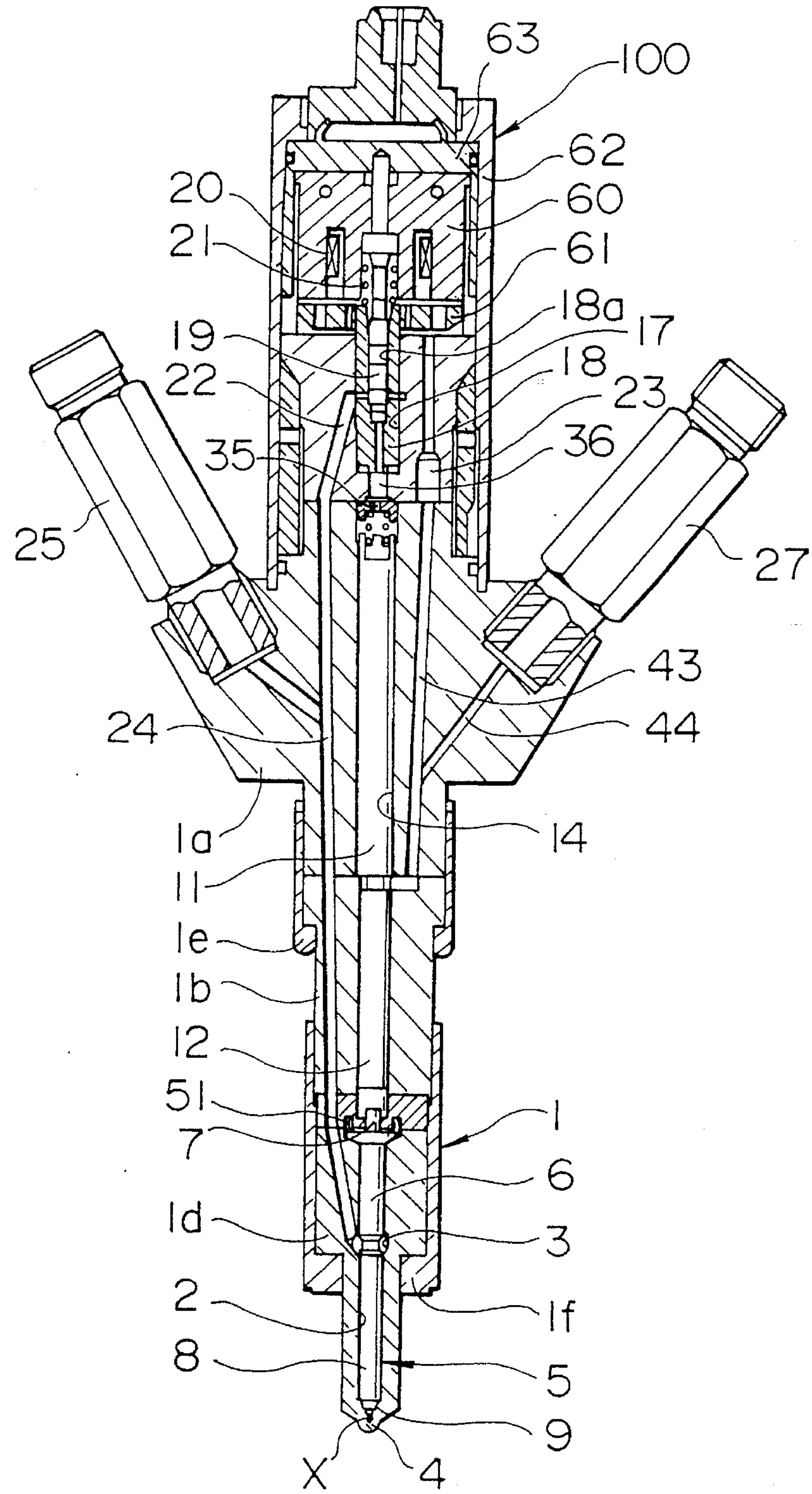
X
4

FIG. 2


63
100
62
60
61
20
21
18a
17
19
18
22
23
35
36
25
27
43
44
24
1a
14
11
1e
1b
12
51
1
7
6
1d
3
2
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9
X
4

FIG. 3

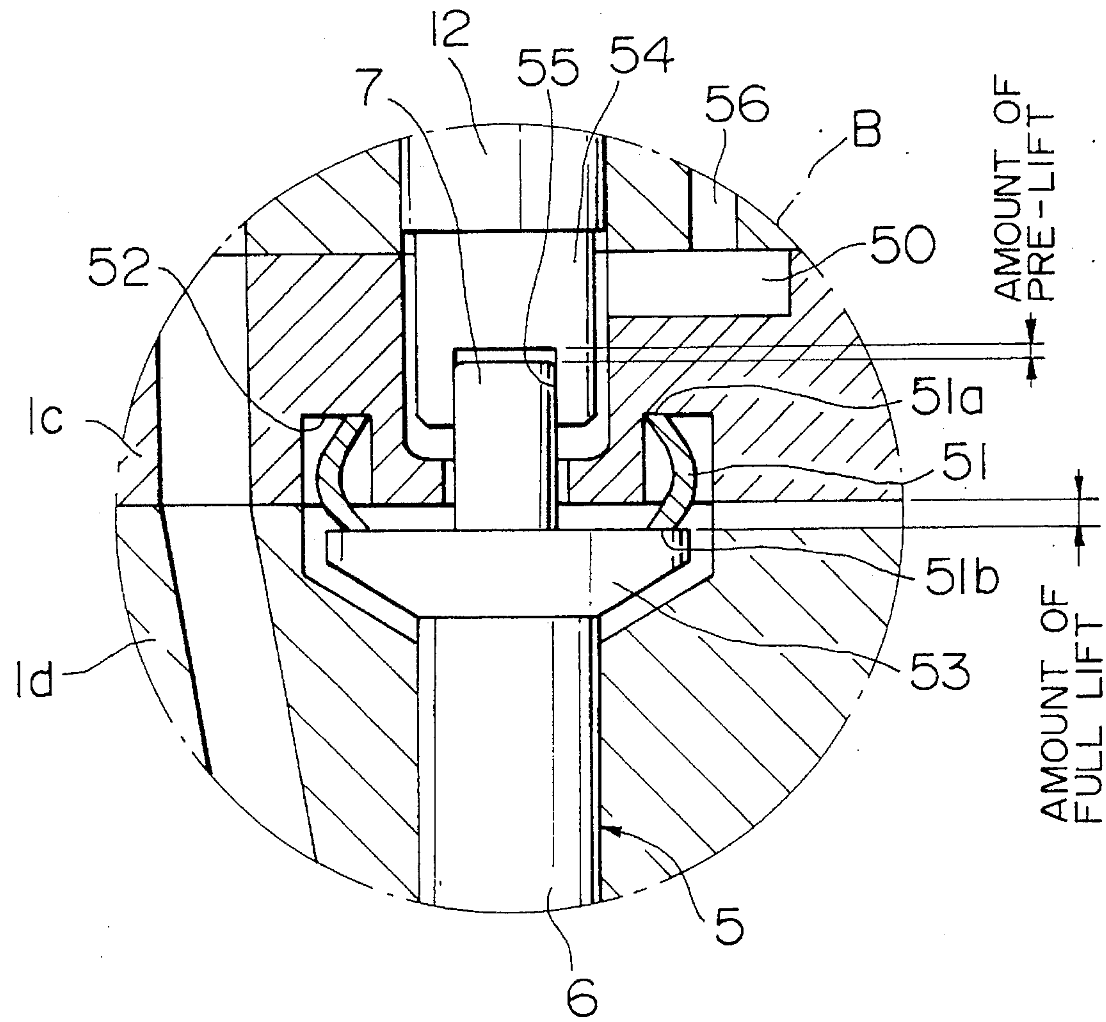

12
7
55
54
56
B
52
50
AMOUNT OF PRE-LIFT
51a
1c
51
51b
AMOUNT OF FULL LIFT
53
1d
5
6

FIG. 4

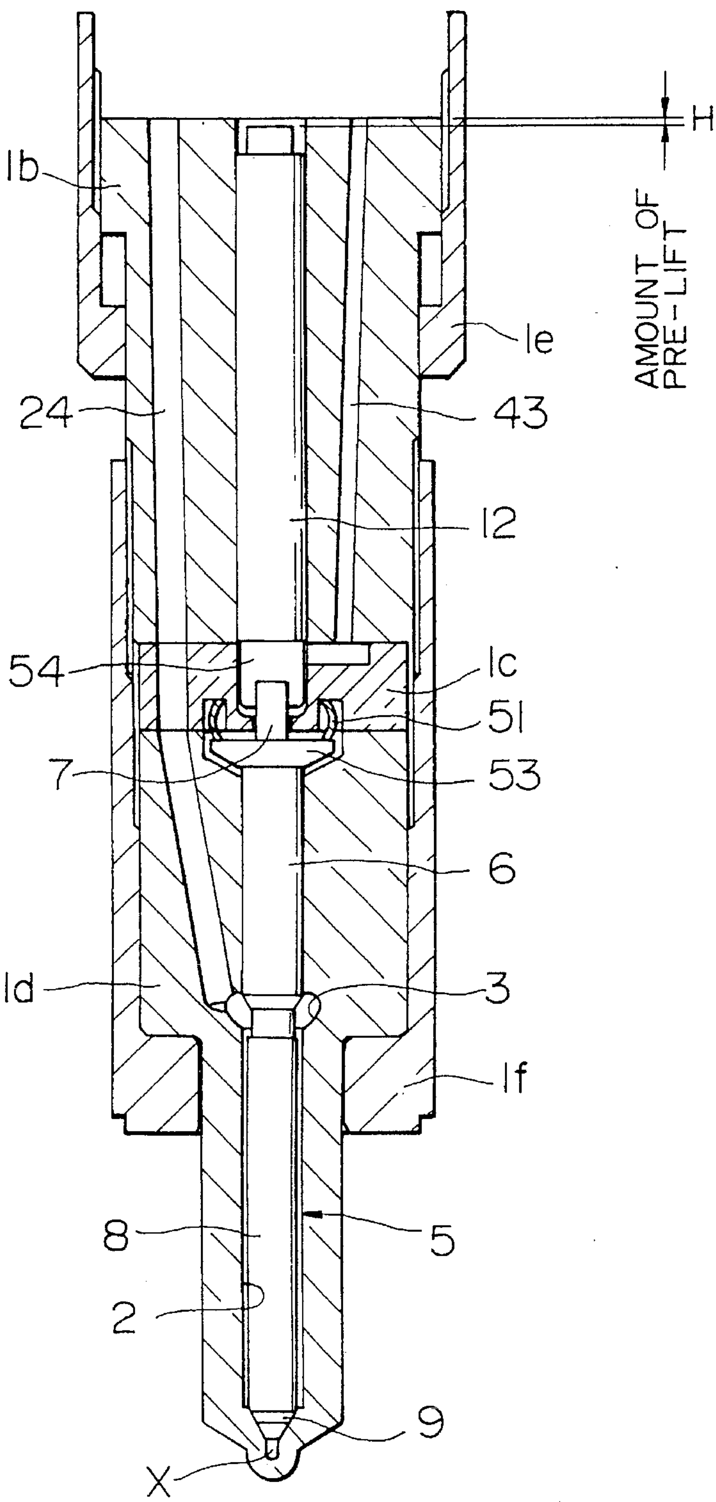


FIG. 5

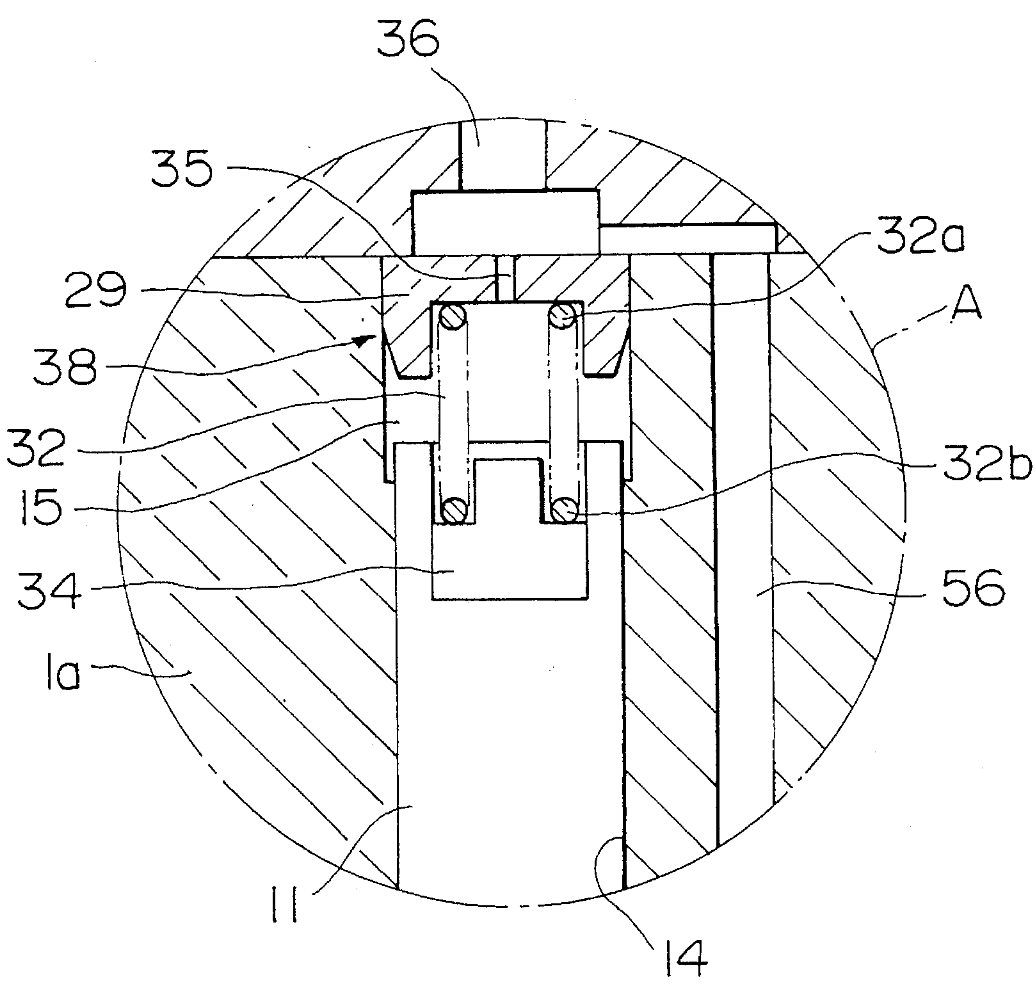


FIG. 6

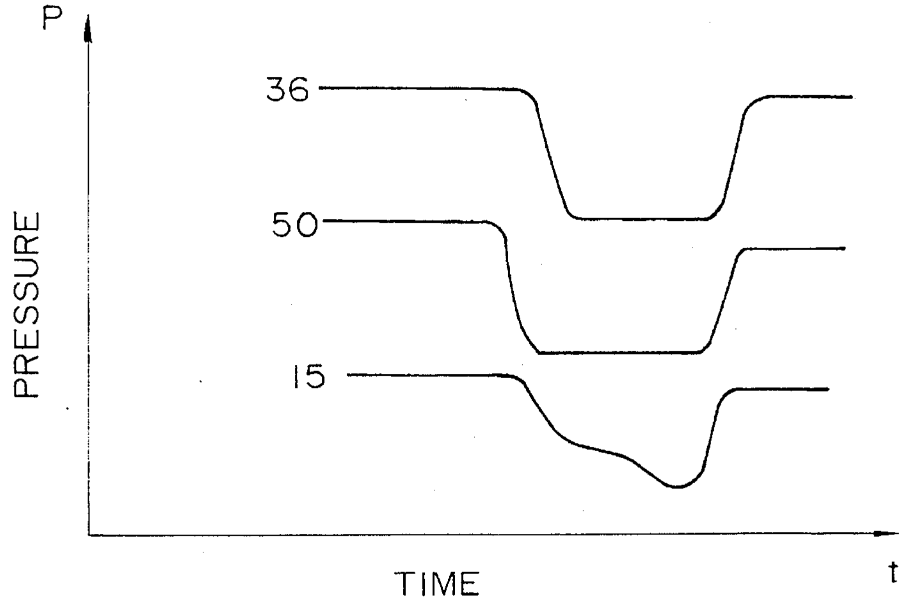


FIG. 7

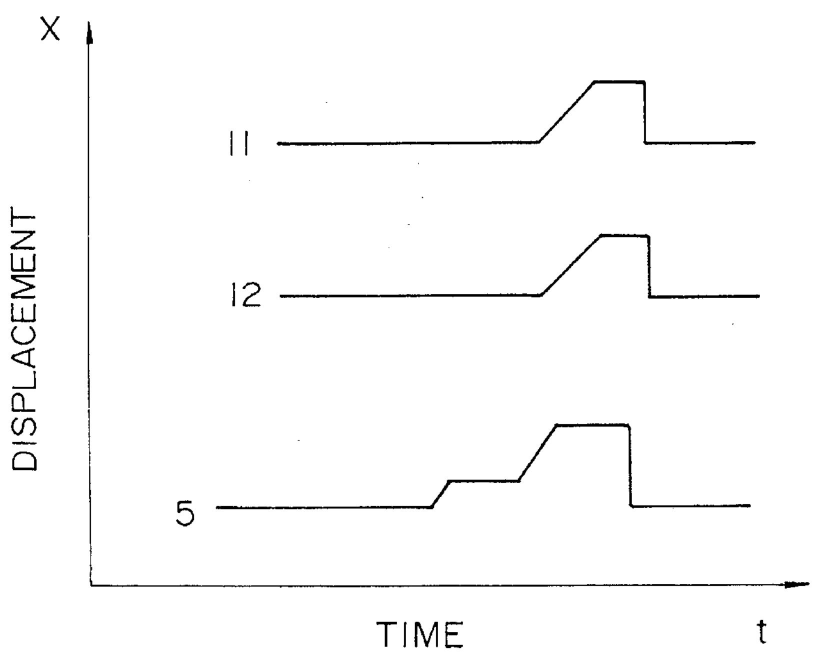


FIG. 8

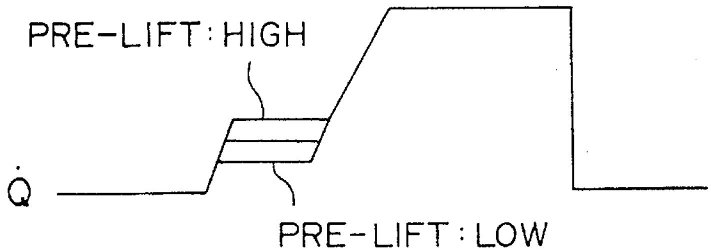


FIG. 9

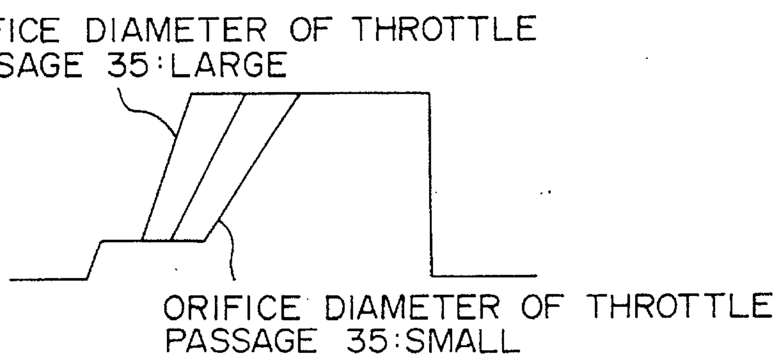


FIG. 10

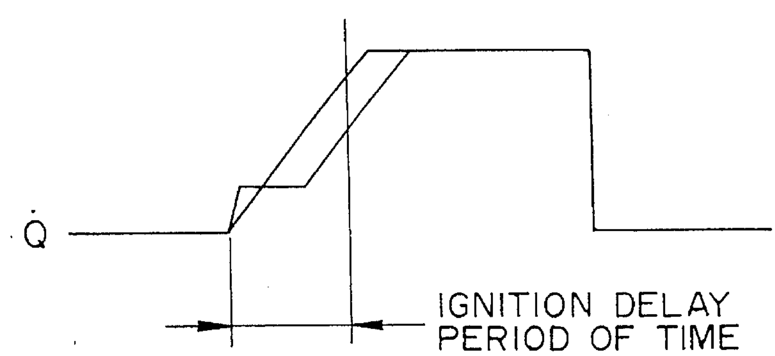


FIG. 11

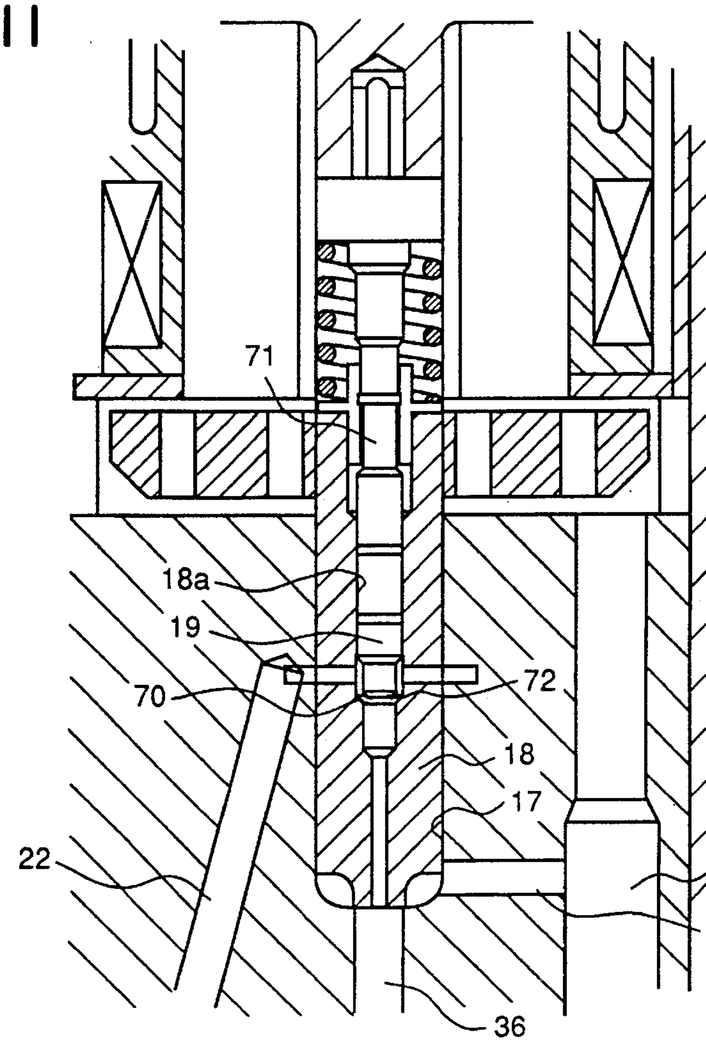
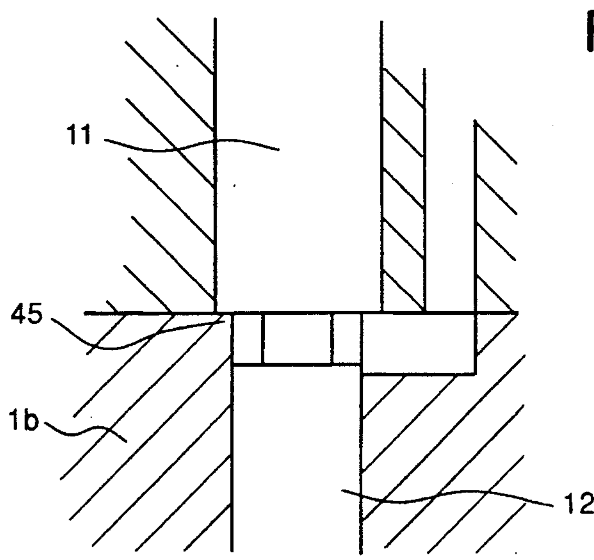


FIG. 12



ACCUMULATOR FUEL INJECTION APPARATUS

This is a continuation-in-part of application Ser. No. 8/103,698, filed on Aug. 10, 1993, now abandoned.

BACKGROUND OF THE INVENTION

The present invention relates to an accumulator fuel injection apparatus and, more particularly, to a fuel injection apparatus for a diesel engine, which facilitates setting of an amount of pre-lift of a nozzle needle.

As a fuel injection apparatus for a diesel engine, an arrangement has been disclosed, for example, in U.S. Pat. No. 5,156,132, which comprises common accumulator piping called a common rail for accumulating high-pressure fuel, and an injector for injecting the fuel. A nozzle needle for opening and closing an injection bore is slidably arranged within the injector. The nozzle needle defines a back-pressure chamber for retaining fuel pressure which acts on the nozzle needle. Pressure within the back-pressure chamber is so controlled as to be switched to fuel pressure on the high-pressure side and fuel pressure on the low-pressure side by a three-way electromagnetic valve. Thus, the high-pressure fuel supplied from the accumulator piping is injected from the injection bore. In order to improve engine performance, pre-lift of a nozzle needle is so set as to achieve boot-type injection which is such an injection rate that an amount of injection at the initial time of injection is constant, the amount of injection is made substantially constant after the amount of injection rises again, and running-out of the injection is completed instantaneously.

For the conventional fuel injection apparatus for the diesel engine having an arrangement of the kind referred to above, however, the amount of pre-lift of the nozzle needle which determines or decides the initial amount of injection is decided by the uppermost portions of the group of parts which are moved together with the nozzle needle. Accordingly, there is a problem that dimensional management or administration of a plurality of parts in a longitudinal direction and an estimate of longitudinal deformation of the parts due to hydraulic pressure are extremely difficult.

SUMMARY OF THE INVENTION

It is an object of the invention to provide an accumulate fuel injection apparatus in which an amount of pre-lift in boot-type injection is set by a gap between a nozzle needle and a piston thereabove, whereby setting operability of the amount of pre-lift and assembling operability of the nozzle needle are improved.

According to the invention, there is provided an accumulator fuel injection apparatus comprising: a casing element formed therein with a guide bore; a nozzle body reciprocally guided in the guide bore; a first pressure control chamber against which a one end side of the nozzle body faces; an injection bore; a seat provided at the other end side of the nozzle body for opening and closing the injection bore; accumulator piping in which high-pressure fluid is accumulated; a low-pressure chamber; and a control valve, wherein the first pressure control chamber communicates with the accumulator piping, and the low-pressure chamber in switching by the control valve, to reciprocate the nozzle body, to thereby control the injection bore in opening and closing, and wherein the nozzle body is divided into a first nozzle having the one end side and a second nozzle having the other end side, the accumulator fuel injection apparatus

further comprising: a stopper for setting a maximum-movement position of the first nozzle toward the second nozzle; a second pressure control chamber communicating in switching with the accumulator piping and the low-pressure chamber in synchronism with the first pressure control chamber, by the control valve, and for forming a predetermined interval through which the first nozzle and the second nozzle are spaced away from each other, under a condition that the first nozzle is arranged at the maximum movement position; and delay means for delaying reduction of the pressure within the first pressure control chamber due to the fact that fluid flows into the low-pressure chamber from the first pressure control chamber upon communication of the first pressure control chamber and the low-pressure chamber with each other.

Accordingly, with the accumulator fuel injection apparatus according to the invention, the nozzle body is divided into a plurality of elements, which have conventionally been united together, and the nozzle body is provided in which the maximum-movement position is set. It is possible to set the amount of pre-lift by a location between one end to the other end of the nozzle body.

Moreover, according to the invention, there is further provided an accumulator fuel injection apparatus comprising: accumulator piping accumulating therein high-pressure fuel; a first piston reciprocally guided in a guide bore formed in a lower element and having a one end side thereof which faces a first pressure control chamber; a stopper for setting a maximum movement position toward the other end side of the first piston; a second piston reciprocally guided in a guide bore formed in a spacer, and having a one end side thereof abutted against the other end of the first piston and the other end side facing a second pressure control chamber which communicates with the first pressure control chamber; a nozzle needle whose one end side faces the second pressure control chamber, the nozzle needle having a seat at the other end side of the nozzle needle; a valve casing having a guide bore for reciprocally guiding the nozzle needle, a valve seat abutted against the seat of the nozzle needle, and an injection bore; delay means for delaying reduction of pressure within the first pressure control chamber due to the fact that fluid flows into a low-pressure chamber from the first pressure control chamber upon communication of the first pressure control chamber and the low-pressure chamber with each other; and biasing means for spacing the second piston and the nozzle needle away from each other so as to form a predetermined gap between the other end side of the second piston and the one end side of the nozzle needle under a condition that the first piston is arranged at the maximum movement position.

Accordingly, with the accumulator fuel injection apparatus according to the invention, it is possible to manage or administer setting of the amount of pre-lift of the nozzle needle by the spacer and the second piston. Thus, it is possible to facilitate operation of adjustment of the amount of pre-lift and operation of maintenance and inspection.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. **1** is a cross-sectional view showing a fuel injection apparatus for a diesel engine, according to an embodiment of the invention;

FIG. **2** is a cross-sectional view showing the fuel injection apparatus for the diesel engine illustrated in FIG. **1**, the cross-sectional view being cut in a cross-sectional surface different from that shown in FIG. **1**;

FIG. 3 is an enlarged cross-sectional view showing a portion B in FIG. 1;

FIG. 4 is a cross-sectional view showing the fuel injection apparatus for the diesel engine illustrated in FIG. 1, describing operation of setting the amount of pre-lift prior to completion of assembling;

FIG. 5 is an enlarged cross-sectional view showing a portion A illustrated in FIG. 1;

FIG. 6 is a time chart showing pressure changing characteristic of the above-described embodiment of the invention;

FIG. 7 is a time chart showing displacement characteristic of the above-mentioned embodiment of the invention;

FIG. 8 is a view for describing the injection characteristic of the above-described embodiment of the invention;

FIG. 9 is a view for describing the injection characteristic of the above-described embodiment of the invention;

FIG. 10 is a view for describing the injection characteristic of the above-described embodiment of the invention;

FIG. 11 is an enlarged cross-sectional view of a portion of FIG. 1 showing the three-way electromagnetic valve 16; and

FIG. 12 is an enlarged cross-sectional view showing stopper 45 in FIG. 1.

PREFERRED EMBODIMENT OF THE INVENTION

An embodiment of the invention will hereunder be described with reference to the accompanying drawings.

Referring first to FIG. 1, an injector **100** has a casing **1** which comprises a lower element **1***a*, a spacer **1***b*, a distance piece **1***c* and a valve casing element **1***d*. The lower element **1***a* and the spacer **1***b* are coupled together by a first retaining ring **1***e*. The spacer **1***b*, the distance piece **1***c* and the valve casing element **1***d* are coupled together by a second retaining ring **1***f*. A valve sliding bore **2** and a fuel reservoir chamber **3** are defined in the valve casing element **1***d*. A nozzle needle **5** has a larger diameter portion **6** which is slidably fitted in the valve sliding bore **2** which communicates with the fuel reservoir chamber **3**. A connecting portion **7** is formed at the larger diameter portion **6** of the nozzle needle **5**. A smaller-diameter portion **8** and a valve portion **9** are integrally formed at a location below the connecting portion **7**. A seat x is opened and closed by the valve portion **9** so that injection from a jetting or injection bore **4** is turned on and off.

A first piston **11** is slidably fitted within a cylinder **14** which is defined in the lower element **1***a*. The first piston **11** is abutted against one end of a second piston **12**. The other end of the second piston **12** is formed with a smaller-diameter portion **54**, as shown in FIG. **3**. The connecting portion **7** of the nozzle needle **5** has a forward end thereof which is slidably fitted in a cylinder **55** formed in the smaller-diameter portion **54**.

A first pressure control chamber **15** is defined within the cylinder **14**, as shown in FIG. **5**, to form a one-way orifice **38**. The first pressure control chamber **15** communicates with a passage **36** through a restriction passage **35** which is defined in a valve body **29**. A compressive coil spring **32** has one end **32***a* thereof which is abutted against the valve body **29**. The other end **32***b* of the compressive coil spring **32** is abutted against the first piston **11** through a valve seat **34**. If high pressure is introduced to a passage **36** from a passage **22** through an inner valve **19** and an outer valve **18**, the valve body **29** is depressed or is moved downwardly so that the compressive coil spring **32** and the valve body **29** are abutted against the first piston **11** to push down the first piston **11**. At this time, high-pressure fuel flows into the first pressure control chamber **15** from a restriction passage **35** so that the pressure within the first pressure control chamber **15** is soon raised to high pressure. Then, when the passage **36** is switched to low pressure, the fuel flows out from the restriction passage **35** until pressure balance of the first pressure control chamber **15** is broken, to maintain the first piston **11** under a depressed condition. Subsequently, when the first pressure control chamber **15** is reduced to low pressure, pressure balance of the first pressure control chamber **15** is broken so that the first piston **11** lifts or is moved upwardly.

A second pressure control chamber **50** communicates with the passage **36** through a high-pressure fuel passage **56**. As shown in FIG. **3**, an annular spring element **51** is received within the second pressure control chamber **50**. The annular spring element **51** has one end **51***a* thereof which is abutted against an annular groove **52** which is formed in a bottom surface of the distance piece *c*. The other end **51***b* of the annular spring element **51** is abutted against a larger-diameter spring seat **53** which is formed at a rearward end of the nozzle needle **5**. The connecting portion **7** is slidable vertically within the cylinder **55** which is defined in the smaller-diameter solid cylindrical portion **54** which is formed at a rearward end of the second piston **12**. Here, as shown in FIG. **3**, an amount of full lift and an amount of pre-lift of the nozzle needle **5** are decided. The amount of pre-lift H is decided by a difference between the spacer **1***b* and a top of the second piston **12** illustrated in FIG. **4** upon assembling.

Referring back to FIG. **1**, the three-way electromagnetic valve (control valve) **16** is arranged above the first piston **11**. The three-way electromagnetic valve (control valve) **16** comprises valve means and magnetizing or exciting means. The valve means has the outer valve **18** slidably guided by a cylinder **17**, and the inner valve **19** slidably guided by an internal bore **18***a* in the outer valve **18**. The inner valve **19** slides in the internal bore **18***a* depending on the fuel pressure from the passage **22**. As shown in FIG. **11**, the inner valve **19** has a seat portion **72** at the bottom, which seats on a valve seat **70** of the outer valve **18** to interrupt fuel flow between the passage **22** and the bore **36**. The upper movement of the inner valve **19** is limited by the stopper **71**. The exciting means has a coil **20** mounted on a solenoid housing **63**, a stator **60** fixedly mounted on a case **62** through the solenoid housing **63**, a movable core **61** fixedly mounted on the outer valve **18** and attracted against the stator **60** upon energization, and a compressive coil spring **21** for biasing the outer valve **18** toward a side opposite to the attracting side.

When the coil **20** is deenergized, the outer valve **18** is located at a lower position by a biasing force of the compressive coil spring **21**. In case high-pressure fuel is supplied from passage **22** into the outer valve **18** through radial passages of the outer valve **18**, the inner valve **19** is pushed upwardly by the high fuel pressure and is stopped in its upward movement by stopper **71**, as shown in FIG. **11**. Passage **22** and the first pressure control chamber **15** communicate with each other through the passage **36**. Further, when the coil **20** is energized, the outer valve **18** is moved upwardly. At this time, the seat portion **72** of the inner valve **11** seats on the valve seat **70** of the outer valve **18**, and the fuel flow between the passage **22** and the bore **36** is interrupted. On the other hand, the first pressure control chamber **15** and the drain passage **23** communicate with each other via a passage **73**. In this connection, as shown in FIG. **2**, fuel within a drain passage **23** can be drawn to a drain tank (not shown) through passages **43** and **44** and an outlet **27**.

The detailed description of the three-way electromagnetic valve **16** is referred to in U.S. Pat. Nos. 5,125,575 and 5,156,132, the relevant content of which is incorporated herein by reference.

The casing **1** is formed therein with a fuel supply passage **24**. The fuel supply passage **24** has one end thereof which is connected to the fuel reservoir chamber **3** and the other end which is connected to the passage **22** in the three-way electromagnetic valve **16**. An accumulator piping **26** accumulates high-pressure fuel which is supplied from a high-pressure supply pump (not shown). The accumulator piping **26** supplies the high-pressure fuel to the injectors **100** arranged respectively for cylinders, through an inlet **25**. Signals from a cylinder judgment sensor, a cam-angle sensor, an accelerator-opening sensor and the like are inputted to a controller **28** so that the controller **28** controls the three-way electromagnetic valve **16** at predetermined fuel injection timing.

Operation will next be described.

The high-pressure fuel in the accumulator piping **26** is supplied into the injector **100** through the inlet **25**. The fuel is supplied to the fuel reservoir chamber **3** through the fuel supply passage **24**, and is supplied to the three-way electromagnetic valve **16**.

At this time, in a case where the three-way electromagnetic valve **16** is deenergized, the outer valve **18** is seated by the compressive coil spring **21**. The fuel supplied to the three-way electromagnetic valve **16** moves the inner valve **19** upwardly in the figures. The seat portion **72** is apart from the valve seat **70** and fuel flows into the passage **36** through the radial passages as shown in FIG. **11**.

The fuel flowing into the passage **36** flows into the first pressure control chamber **15** through the restriction passage **35**. Under a condition in which predetermined time elapses, the first pressure control chamber **15** is filled with the high-pressure fuel. At this time, the first pressure control chamber **15**, the second pressure control chamber **50** and the fuel reservoir chamber **3** are high in pressure. The first piston **11** is abutted against a stopper **45**. The stopper **45** is formed as a circumferential shoulder on the upper end surface of the spacer **1*b***, as shown in FIG. **12**. The lower movement of the piston **11** is limited by the stopper **45**. At this time, the second piston **12** is abutted against the first piston **11**. The nozzle needle **5** is seated upon the seat x by a difference between a pressure receiving area within the second control chamber and a pressure receiving area at the fuel reservoir chamber **3** and the setting force of the annular spring element **51**.

When the three-way electromagnetic valve **16** is excited or energized, the outer valve **18** is attracted upwardly in the figures. At this time, the seat portions **72** seats on the valve seat **70**, and the fuel flow between the passage **22** and the bore **36** is interrupted. Therefore, the bore **36** communicates with the drain **23** through passage **73**, the fuel within the first pressure control chamber **15** escapes toward the low pressure side through the passage **36** and the drain passage **23**. At this time, however, the first pressure control chamber **15** is restricted in outflow of the fuel by the restriction passage **35**. Accordingly, the pressure within the first pressure control chamber **15** is not at once reduced, but is maintained to high pressure during a predetermined period of time. Thus, the first piston **11** is retained to a condition abutted against the stopper **45**. At this time, the second piston **12** is located while being abutted against the first piston **11**. The nozzle needle **5** rises or is moved upwardly by the amount of pre-lift indicated in FIG. **3**, by a difference between pressure (low pressure) received by the pressure receiving area of the second pressure control chamber **56** and pressure (high pressure) received by the pressure receiving area at the fuel reservoir chamber **3** and the setting pressure of the annular spring element **51**.

Subsequently, when the pressure within the first pressure control chamber **15** is reduced to a level so bearing as to raise the first piston **11** and the second piston **12**, the first piston **11** and the second piston **12** are brought to a full-lift condition.

Subsequently, when the three-way electromagnetic valve **16** is deenergized, the high-pressure fuel is supplied to the fist pressure control chamber **15** and the second pressure control chamber **50** through the three-way electromagnetic valve **16** and the passage **36**. Then, the first piston **11** receives the pressure within the first pressure control chamber **15** and is instantaneously moved downwardly in the figures. In keeping therewith, the second piston **12** and the nozzle needle **5** are moved downwardly. Thus, injection has soon come to an end.

In connection with the above, FIG. **6** is a time chart showing pressure variation or change of the passage **36**, the second pressure control chamber **50** and the first pressure control chamber **15** due to the above-described operation. FIG. **7** is a time chart showing displacement of each of the first piston **11**, the second piston **12** and the nozzle needle **5** in the above-mentioned operation. As shown in FIG. **8**, an amount of pre-lift can be adjusted by axial length of each of the distance piece **1*c*** and the spacer **1*b*** illustrated in FIG. **4**. Further, as shown in FIG. **9**, by regulation or adjustment of the restriction diameter of the restriction passage **35**, it is possible to control an inclination of full-lift ascending of the nozzle needle **5**. Moreover, as shown in FIG. **10**, since it is possible to reduce the amount of injection during a period of ignition lag or delay time as compared with the conventional delta-type injection, it is possible to prevent dash combustion from occurring to reduce nitrogen oxides.

With the arrangement of the embodiment, as shown in FIG. **4**, upon assembling, the second piston **12** is abutted against the nozzle needle **5**, and the amount of pre-lift H is set by a step between the second piston **12** and the spacer **1*b***. Setting of the amount of pre-lift H of the nozzle needle **5** can be managed only by the step H between the spacer **1*b*** and the top of the second piston **12** illustrated in FIG. **4**. Conventionally, the longitudinal size of the lower element has controlled or governed the amount of pre-lift. In the present embodiment, however, dimensional management of the lower element **1*a*** is dispensed with because the amount of pre-lift is decided. Accordingly, setting of the amount of pre-lift is facilitated. Furthermore, only rearrangement of the various parts illustrated in FIG. **4** into a body by the retaining ring **1*e*** makes it possible to perform operation of adjustment of the amount of pre-lift and operation of inspection and maintenance. Thus, there is provided an advantage that serviceability is improved.

Since elastic deformation of the annular spring element **51** is relatively low as compared with that of the compressive coil spring upon assembling of the annular spring element **51** in the aforesaid embodiment, there is also provided an advantage that the amount of pre-lift can always be maintained properly or adequately.

As described above, the fuel injection apparatus for the diesel engine, according to the invention, enables the boot-type injection and decides the amount of pre-lift of the nozzle needle which decides the injection rate, by the intermediate portion of the group of parts which are moved together with the nozzle needle. Accordingly, there are produced advantages that the operation of setting of the amount of pre-lift is facilitated, and operability upon maintenance and inspection is also improved. Moreover, there are produced the following advantages. That is, when the amount of pre-lift of the nozzle needle is decided, management of the longitudinal dimension of the plurality of parts which cooperate to form the injector is facilitated. Furthermore, an estimate of the longitudinal deformation of the parts due to the hydraulic pressure is facilitated.

What is claimed is:

1. An accumulator fuel injection apparatus comprising:

a casing element formed therein with a guide bore;

a nozzle element reciprocally guided in said guide bore;

a first pressure control chamber against which one end side of said nozzle element faces;

an injection bore;

a seat provided at another end side of said nozzle element for opening and closing said injection bore;

accumulator piping in which high-pressure fluid is accumulated;

a low-pressure chamber; and

a control valve,

wherein said first pressure control chamber communicates with said accumulator piping, and said low-pressure chamber in switching by said control valve, to reciprocate said nozzle element, to thereby control said injection bore in opening and closing, and

wherein said nozzle element is divided into a first piston having said one end side of said nozzle element and a second piston having said other end side of the nozzle element,

said accumulator fuel injection apparatus further comprising:

a stopper for setting a maximum-movement position of said first piston toward said second nozzle;

a second pressure control chamber communicating in switching with said accumulator piping and said low-pressure chamber in synchronism with said first pressure control chamber, by said control valve, and for forming a predetermined interval through which said first piston and said second piston are spaced away from each other, under a condition that said first piston is arranged at said maximum movement position; and

delay means for delaying reduction of the pressure within said first pressure control chamber due to the fact that fluid flows into said low-pressure chamber from said first pressure control chamber upon communication of said first pressure control chamber and said low-pressure chamber with each other.

2. An accumulator fuel injection apparatus, according to claim **1**, wherein said delay means is a one-way orifice.

3. An accumulator fuel injection apparatus comprising:

accumulator piping accumulating therein high-pressure fuel;

a first piston reciprocally guided in a guide bore formed in a lower element and having one end side thereof which faces a first pressure control chamber;

a stopper for setting a maximum movement position toward the other end side of said first piston;

a second piston reciprocally guided in a guide bore formed in a spacer, and having one end side thereof abutted against the other end of said first piston and the other end side facing a second pressure control chamber which communicates in switching with said accumulator piping and a low pressure chamber in synchronism with said first pressure control chamber, by a control valve;

a nozzle needle whose one end side faces said second pressure control chamber, said nozzle needle having a seat at the other end side of said nozzle needle;

a valve casing having a guide bore for reciprocally guiding said nozzle needle, a valve seat abutted against the seat of said nozzle needle, and an injection bore;

delay means for delaying reduction of pressure within said first pressure control chamber due to the fact that fluid flows into a low-pressure chamber from said first pressure control chamber upon communication of said first pressure control chamber and said low-pressure chamber with each other; and

biasing means for spacing said second piston and said nozzle needle away from each other so as to form a predetermined gap between the other end side of said second piston and said one end side of said nozzle needle under a condition that said first piston is arranged at said maximum movement position.

4. An accumulator fuel injection apparatus according to claim **3**, further comprising pre-lift-amount deciding means for connecting said second piston and said nozzle needle to each other so as to be variable in axial distance within a predetermined range, to decide an amount of pre-lift of said nozzle needle.

5. An accumulator fuel injection apparatus according to claim **4**, wherein said pre-lift-amount deciding means is such that a connecting portion of said nozzle needle is slidably fitted in a cylinder portion formed in said piston.

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